ENTOMOLOGICAL Communications

Entomological Communications, 7, 2025: ec07012
doi: 10.37486/2675-1305.ec070012
e-ISSN: 2675-1305
Open Access Full Text Article

Protocol & Techniques

Reducing Bycatch in Aquatic Insect Sampling: Evaluating a Size-Dependent Exclusion Device for UV Light Pan Traps

Alexander B. Orfinger, Hunter J. Smith

Dalton State College, Dalton, GA, USA.
Corresponding author: aorfinger@daltonstate.edu

Edited by: Paulo V. Cruz

Received: February 18, 2025. Accepted: May 02, 2025. Published: May 29, 2025.

Abstract. A growing body of research indicates that insect populations are declining worldwide, underscoring ongoing anthropogenic threats to biodiversity. Considering these conservation concerns, novel strategies to protect insects and other species vulnerable as bycatch to insect collecting techniques should be considered. These methods should ideally minimize bycatch while not impacting the recovery of target taxa. In the field of aquatic entomology, the UV light pan trap is widely used. While effective, this method incurs significant bycatch of unwanted arthropods and occasionally vertebrates, which both compromises the sample and has conservation implications. The goal herein was to develop and test a size-based bycatch exclusion device deployed with UV light pan traps for reducing non-target catches. This simple, cost-effective design does not require any modifications of the existing trap itself beyond adding a domed cage. "Caged" and "uncaged" traps were simultaneously deployed at two streams in northwest Georgia, USA, for a total of twelve trapping events over three months. Caddisflies (Trichoptera) served as the target taxa, namely net-spinning caddisflies (Hydropsychidae) and microcaddisflies (Hydroptilidae), and total numbers of these were counted and compared between caged and uncaged traps. No significant differences were detected between treatments. Therefore, the data suggest that these exclusion devices do not negatively impact adult caddisfly sampling and should exclude undesired large insects, such as dobsonflies, certain saturniid moths, and many vertebrates. Although these results are positive, they are preliminary, and additional questions must be addressed which are discussed in this study.

Keywords: Aquatic entomology, Conservation, Faunistics, Residue, Trichoptera.

Faunistic collections are a fundamental component in numerous applications of evolutionary and ecological sciences. In taxonomy, systematics, biodiversity studies, and water quality evaluation, for example, light traps are routinely used to collect aquatic insect adults adjacent to water bodies. One of the most common methods is employing a UV light pan trap, in which a UV light bar is connected to a 12-volt battery and laid over a white pan filled with high-percentage ethanol (*sensu* Calor & Mariano 2012). The trap is deployed in the evening and retrieved after several hours of nightfall. During that time, flying insects are attracted to the light and succumb to the alcohol. This method is economical and effective. However, this is a non-specific sampling method that inevitably captures numerous non-target taxa. These bycatch or "residue" samples increase sample processing time and can damage the target taxa (e.g., moths shed scales that coat specimens of interest, obscuring the morphology of taxa of interest). Perhaps most importantly, this method unnecessarily kills fauna including other insects, non-insect arthropods, and even vertebrates like reptiles and amphibians (e.g., Orfinger 2021; ABO personal observations).

During the ongoing "insect apocalypse", it is now more important than ever to mitigate unnecessary invertebrate mortality (Cardoso et al. 2020). Towards this goal, this project sought to construct and evaluate an economical and size-dependent bycatch exclusion device to reduce undesired bycatch. Bycatch exclusion devices have been effectively adopted in other fields; for example, several global commercial fisheries utilize turtle exclusion devices to reduce unwanted sea turtle bycatch (Tookes et al. 2023). To the authors' knowledge, no such device has been formally attempted in insect light trapping, and this is the first effort to do so, manifested as a durable, inexpensive device constructed with readily available materials.

A dome-shaped exclusion device sufficiently large to surround the pan trap was constructed using 3.5 cm mesh galvanized steel chicken wire as a barrier, and narrow (6.35 mm width) and pliable but sturdy aluminum wiring as the scaffold. The scaffold was constructed using two wire strips intersecting centrally at the vertex in an "X"-shape and each arced at 180° (Fig. 1). The chicken wire was secured to the frame using small, white cable ties trimmed flush to the frame, thereby avoiding the potential sensory influence of chemical fixatives on insects. When deployed, the exclusion device was anchored to the ground using galvanized steel stakes to prevent movement. The exclusion device has a base diameter of 55 cm and a center height of 38 cm.

To evaluate the efficacy of the exclusion device, two locations were sampled once monthly for three consecutive months, namely 15-16 April, 15-16 May, and 15-16 June 2024, for a total of six caged and six uncaged trap trials. Traps were deployed at each site 30 minutes before official sunset and retrieved 1.5 hours after official sunset. Sampling sites were the upper reaches of College Creek (34.7755, -85.0096), a first order stream on Rocky Face Ridge on the Dalton State College (DSC) campus in Whitfield County, Georgia, USA and a second order unnamed tributary of Dick Creek (34.61989, -85.14619) in Walker County, Georgia, USA. Permission to sample the latter site was granted by the landowners.

At each site during each sampling event, two traps were deployed simultaneously; on one side of each stream, a cage-free light trap was used, and on the other side of the stream, a caged trap was used. The traps were placed in the same stream location on opposite banks for each sampling event, 1 m from the water edge and in as open an area as possible to maximize insect sightline. Each trap's samples were taken back to the lab at DSC for processing. Two cosmopolitan and common caddisfly (Trichoptera) families representing distinct size classes - the Hydroptilidae, or microcaddisflies (small, <5 mm length) and the Hydropsychidae, or net-spinning caddisfly (medium, 6-19 mm), were sorted and identified. Insufficient numbers of large (>20 mm) caddisflies like those in the family Limnephilidae were recovered to

Figure 1. Size-dependent bycatch exclusion device deployed over UV light pan trap at unnamed tributary of Dick Creek in Walker County, Georgia, USA. Shown before nightfall for clarity.

analyze. Caddisflies were sorted and identified to family using the adult family key of Merritt et al. (2023). Specimens are vouchered at DSC.

Total hydropsychid and hydroptilid data per month were analyzed, both pooled by uncaged and caged treatments and analyzed separately by family according to treatment. In each analysis, after ensuring that all assumptions of parametric analysis have been satisfied following a log transformation, a single-factor ANOVA was used to detect any significant differences between caged and non-caged sampling methods. From these analyses, the bycatch exclusion device's impact, if any, on the capture rate of common caddisflies was determined. All analyses were performed using PAST v. 4.14 (Hammer & Harper 2001).

Caged UV light pan traps (n = 6) recovered a mean number of combined hydroptilid and hydropsychid caddisflies of 42.2 (±11.1) versus uncaged traps (n = 6) that yielded an average of 64.7 (±16.9) combined hydroptilid and hydropsychid caddisflies. The spread of the data in the respective treatments is presented in Fig. 2. No significant difference in the number of recovered hydroptilid and hydropsychid caddisflies was detected in either the pooled family ANOVA or the individual family ANOVAs ($p > 0.1$).

Despite the higher average number of Trichoptera (Hydropsychidae + Hydroptilidae) recovered from the uncaged treatments, no significant differences were detected between caged and uncaged light traps. This result suggests that the bycatch exclusion device does not significantly affect the sampling efficiency of adult caddisflies, while effectively excluding larger vertebrate taxa and large, non-target insects. For instance, during several trapping events, a large female eastern dobsonfly [*Corydalus cornutus* (Linnaeus, 1758) (Megaloptera: Corydalidae)] was observed attracted to a caged trap but remained resting on the mesh rather than entering, thereby being excluded. Similar observations were made with geometrid and saturniid moths; however, the number of large moths (>7 cm wingspan) from these families recovered (n = 5) was insufficient for statistical comparison.

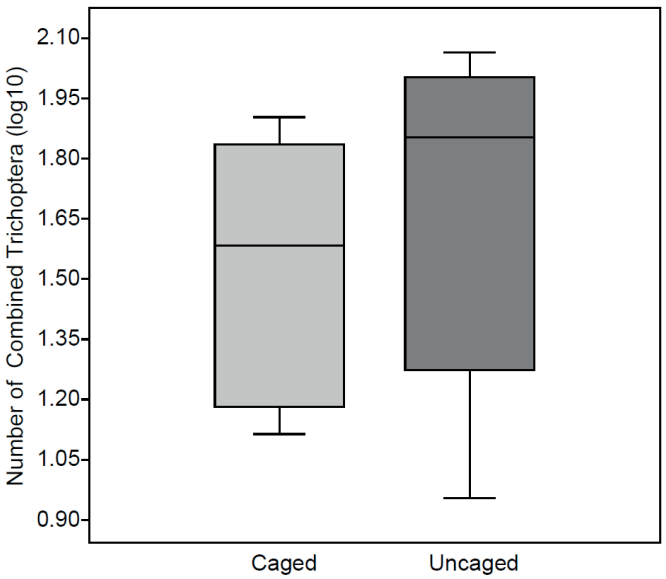

Figure 2. Boxplot of combined number (log transformed) of pooled net-spinning caddisfly (Hydropsychidae) and microcaddisflies (Hydroptilidae) collected in caged (n = 6) and uncaged (n = 6) treatments.

While promising, the data presented here are preliminary and necessitate further exploration. For example, additional replicates, testing in different habitats such as large rivers and lentic systems, and other biogeographic realms such as the tropics, will better elucidate the efficacy of these cages in excluding unwanted bycatch and not impacting target taxa capture. Constructing and testing exclusion devices with various mesh sizes would also be worthwhile. Indeed, tailoring mesh size per target taxon may be appropriate. In addition,

it is unknown to what extent small animals not physically excluded from the cages may be behaviorally excluded should they simply rest on the cages upon first contact, a behavior that was observed in low but regular frequency across several taxa, e.g., tipulids (Diptera). While not seeming to impact our sampling efforts, this resting behavior could become problematic in areas of dense populations of large phototaxic insects like megalopterans and some moths. Potentially, this could block target taxa from entering or could shield the light source, but this is unknown and would be occasional rather than universal.

The potential importance of bycatch exclusion methods grows each year as the risk to overall biodiversity increases. With growing concern about global insect populations, the use of bycatch exclusion devices is perhaps more relevant than ever. This pattern of global insect decline has been observed with decreasing catch rates of numerous insects over decades (Goulson 2019). The non-specific nature of UV pan trapping results in unnecessary bycatch that can complicate sample sorting and be of potential conservation concern. By using a few cheap and readily available materials, the construction of simple and effective size-dependent bycatch exclusion devices can be applied to UV pan trapping and potentially other non-targeted sampling methods such as pitfall traps. For now, these early data suggest that these cages are worth using by those entomologists interested in minimizing bycatch, assuming the target taxa are less than, e.g., 4 cm in length.

Acknowledgments

The authors thank Mr. Dallas York for allowing us to sample at his property and for his assistance with field work and initial sorting of specimens. Dr. Gleison Desidério provided excellent comments which improved the quality of the manuscript, for which the authors are thankful.

Funding Information

This project was funded by a U.S. Department of Education Title III HSI STEM grant.

Authors' Contributions

ABO: Conceptualization, methodology, formal analysis, investigation, resources, writing-original draft preparation, writing-review and editing, supervision, project administration, funding acquisition; HJS: formal analysis, investigation, resources, writing-original draft preparation, writing-review and editing.

Conflicts of Interest Statement

The authors declare that there are no conflicts of interest.

References

Calor, A. R.; Mariano, R. (2012) UV light pan traps for collecting aquatic insects. *EntomoBrasilis*, 5(2): 164-166. doi: 10.12741/ebrasilis.v5i2.187

Cardoso, P.; Barton, P. S.; Birkhofer, K.; Chichorro, F.; Deacon, C.; Fartmann, T.; Fukushima, C. S.; Gaigher, R.; Habel, J. C.; Hallmann, C. A., et al. (2020) Scientists' warning to humanity on insect extinctions. *Biological Conservation*, 242: 108426. doi: 10.1016/j.biocon.2020.108426

Goulson, D. (2019) The insect apocalypse, and why it matters. *Current Biology*, 29(19): R967-R971. doi: 10.1016/j.cub.2019.06.069

Hammer, Ø.; Harper, D. A. (2001) PAST: paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*, 4(1): 1-9.

Merritt, R. W.; Cummins, K. W.; Berg, M. B. (2019) *An introduction to the aquatic insects of North America*, 5th Ed. USA: Kendall Hunt.

Orfinger, A. B. (2021) *Sternotherus minor* (Loggerhead Musk Turtle) mortality. *Herpetological Review*, 52(1): 132.

Tookes, J. S.; Yandle, T.; Fluech, B. (2023) The role of fisher engagement in the acceptance of turtle excluder devices in Georgia's shrimping industry. *ICES Journal of Marine Science*, 80(3): 407-416. doi: 10.1093/icesjms/fsac062